DSM-based prediction of distortional failure loads of cold-formed steel columns at elevated temperatures

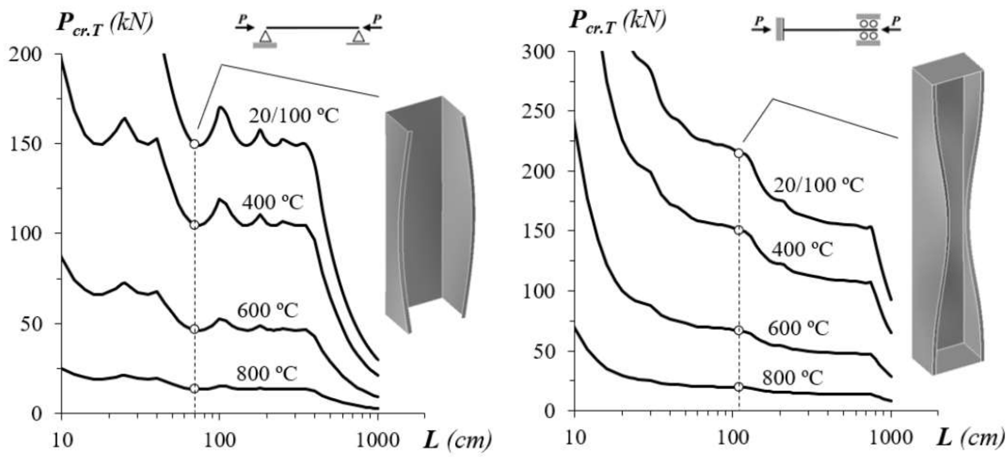
Summary

This thesis was devoted to the numerical investigation of the structural (buckling and post-buckling) behaviour, strength and Direct Strength Method (DSM) design of cold-formed steel columns failing in distortional modes at elevated temperatures, such as those caused by fire conditions. The numerical investigation was carried out by means of ANSYS shell finite element analyses (SFEA), using models validated in previous works. The columns analysed (i) had two end support conditions (fixed-ended and pin-ended supports), (ii) exhibited lipped channel cross-sections with different dimensions (b_w/b_f ratios ranging from 0.7 to 1.4), (iii) had several room temperature yield stresses (which enabled covering a wide distortional slenderness range, up to around 3.5), (iv) contained critical-mode (distortional) initial geometrical imperfections with small amplitudes, and (v) were subjected to eight uniform elevated temperatures (up to 800 °C). In order to simulate the temperature dependence of the steel material properties, the model prescribed in part 1.2 of Eurocode 3 (EC3-1.2) for cold-formed steel was adopted.

After investigating the column elastic and elastic-plastic post-buckling behaviour, an extensive parametric study was carried out to assemble column distortional failure load data. These failure load data were subsequently used to assess the merits (safety, accuracy and reliability of the failure load predictions) of the existing DSM-based distortional strength curves (namely the currently codified one), which were developed and validated in the context of column under room temperature, modified to account for the temperature dependence of the steel material properties. It was found that these DSM-based distortional design curves are unable to predict adequately failure loads of columns under elevated temperatures caused by fire conditions – in other words, they cannot handle appropriately the temperature-dependent steel constitutive model. Finally, on the basis of the numerical failure loads obtained in this work, novel DSM-based design curves were developed for fixed-ended and pin-ended cold-formed steel columns subjected to elevated temperature – it was shown that a significant failure load quality improvement was achieved, particularly in the low-to-moderate distortional slenderness range. design in estimating the ultimate strength of the CFS columns submitted to elevated temperatures. Naturally, experimental validation is indispensable before the proposed DSM-based design approaches can be considered for codification.

Keywords

Cold-formed steel columns, distortional post-buckling behaviour, elevated temperatures, ANSYS shell finite element numerical simulations, Direct Strength Method (DSM) design.



Variation of $P_{cr.T}$ with the length (L) and temperature for pinned and fixed lipped channel columns.

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